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Potatoes and Climate Change

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Potato harvest in the South American highlands. The production of potato – an important crop, also for small farmers – is being affected by climate change in various ways.
(Photo: © chris74 – Fotolia.com)

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Potato farmers feel effects of climate change

Padam Damai grows potatoes in Kathmandu Valley, Nepal. The past year has been an extremely bad one for him and his family. Unusual snowfall in February and hailstorms in summer destroyed much of his crop twice in a row. Extreme weather events have become more frequent also in other potato growing regions of the world. In some areas of the Peruvian highlands, temperatures during the potato season in February dropped down to -30°C , causing major yield losses. In other regions, yields are diminished by drought. Are these events isolated phenomena or are they effects of climate change?

Storms, droughts and floods have troubled mankind for as long as anyone can remember. However, in recent years many places have recorded a marked increase in extreme weather events – a development that scientists clearly attribute to climate change. Although farmers around the world have succeeded in continuously adapting to varying conditions, this frequent occurrence of extreme weather events is confronting them with serious problems. On the occasion of the International Year of the Potato, this issue of InfoResources Focus takes a look at the challenges that climate change poses to agriculture and, more specifically, to potato farming.

Potato – important throughout the world...

As the fourth most important food crop after rice, wheat and maize, potatoes are of invaluable importance for the diets and livelihoods of millions of people worldwide.

The potato embarked on its successful journey around the globe in the 16th century, when the Spanish brought it to Europe from the South American Andes. From here, the potato found its way to Asia in the 17th century, and to Africa in the 19th century. The crop's comparably short vegetation period allows farmers throughout a wide range of different climatic conditions to find an appropriate season for its cultivation.

Global potato production has grown markedly in the past years, particularly due to increased production in developing countries. Improvements in crop varieties, seed potato and cultivation methods have led to higher yields. Moreover, a shift in eating habits in many countries towards more industrially processed potato-based products has boosted demand. In 2005, for the first time, more potatoes were grown in developing countries than in industrialised nations. The main producer is China, with a crop yield of 71 million tonnes, which amounts to over 20% of global production.

... ideal for small farmers

Potatoes belong to the crops that grow even in unfavourable conditions and at high altitudes. Moreover, a few other crops produce a comparably high yield of nutrients per cultivated area – a quality that is particularly welcome in regions where land is scarce. This is why potatoes are highly important for many farming families in the world's mountain regions. High yields and usually favourable sales prices enable manually producing small farmers to be competitive despite the fact that potato cultures require considerable labour input.

Climate Change & Potato Production in Nepal

Experiences of farmers, extension workers and scientists have clearly revealed the changes in weather conditions in Nepal.

Major abiotic problems include prolonged drought, hailstorms and heavy rain and/or irregular patterns of rainfall, sometimes early frost or snowfall, or their late occurrence.

Experiences of farmers of Kathmandu Valley indicate that planting time is slightly earlier compared to 40–50 years back.

Despite changes in climatic conditions, as well as an increase in biotic problems, both total production and productivity of potato is gradually increasing every year. This is due to availability of improved technologies, particularly high-yielding and disease resistant/tolerant varieties, high quality pre-basic and basic seeds, as well as improved production practices and better storage facilities.

Personal communication

SP Dhital – National Potato Research Programme, Nepal

BK Dhital – HELVETAS, Nepal

International Year of the Potato 2008
www.potato2008.org/en/index.html

Adaptation to longer days

The first potatoes brought to Europe from the Andes were ideally adapted to equatorial short-day conditions. In their new growing environment they had to adjust to longer days. This adaptation process took over 150 years.

The Cambridge World History of Food

www.cambridge.org/us/books/kiple/potatoes.htm

Potato production in 2006 (FAOSTAT)

	Harvested area (ha)	Quantity (t)
Africa	1.499.687	16.420.729
Asia/Oceania	9.143.495	131.286.181
Europe	7.348.420	126.332.492
Latin America	951.974	15.627.530
North America	608.131	24.708.603
WORLD	19.551.707	314.375.535

<http://faostat.fao.org>

Nutritional value

Potatoes are rich in carbohydrates. Protein content is fairly low, but of high quality. Content in Vitamin C is remarkably high – one tuber of 150g covers half of the recommended daily amount for an adult. In addition, potatoes are rich in various trace elements.

www.potato2008.org

Documents mentioned in the margin are annotated in the list of references.

... an interesting cash crop

Potatoes are an important source of income for many farmers. In the Andes they are often the only cash crop grown by small farmers. In the tropical lowlands of Bangladesh and India they are cultivated mainly as an irrigated winter cash crop.

Potatoes enjoy particular popularity among farmers in the highlands of Vietnam, who profit from favourable prices. They grow the tubers as a catch crop, in rotation with rice and maize, and while the income they earn from potatoes equals that from rice, it amounts to twice what they could generate from maize and sweet potatoes.

Climate change and its impact on ...

Along with the familiar difficulties related to pests and diseases, potato farmers are increasingly confronted with abiotic problems. Farmers and researchers report an increase in water stress, changes in rainfall distribution and intensity, hail, and increasingly frequent frost and snowfall at high altitudes. The growing frequency of extreme weather events is generally interpreted as clearly related to climate change. The newest report by the Intergovernmental Panel of Climate Change (IPCC), published in 2007, states that global climate warming is an unequivocal fact.

Projections by the IPCC predict a rise in global temperature by 1.8–4°C by the year 2100 due to the increase in greenhouse gases, depending on the scenario. This is expected to have grave consequences for mankind and the environment. The critical threshold is said to be around a temperature increase of 2°C.

Approximately 15% of the total worldwide greenhouse gas emissions are caused by agriculture. An additional 11% result from deforestation, mainly for the purpose of gaining cropland.

Carbon dioxide (CO₂) emissions in agriculture are chiefly caused by the use of fossil fuels during all kinds of agricultural activities, as well as tillage, burning of crop residues, and slash-and-burn deforestation. In addition, agriculture produces around half of the global methane (CH₄) and nitrous oxide (N₂O) emissions. These two greenhouse gases are many times more potent than carbon dioxide.

The main sources of CH₄ are livestock production, irrigated rice cultivation, and storage of manure. N₂O is released into the atmosphere through the soil following the inadequate application of artificial fertilisers and manure.

By taking appropriate measures, agriculture has the possibility of reducing greenhouse gas emissions and thereby actively contributing to the mitigation of climate change.

... agriculture

Agricultural production is highly dependent on climate and weather factors. The impact of climate change on agriculture is accordingly high.

In some regions, drought is leading to water becoming an even more valuable good, while other regions are affected by increasingly frequent flooding or even have to cope with both phenomena.

All projections are based on simulations and therefore involve uncertainties. However, it is clear that climate change will affect different cultivation systems and crop cultures to a varying degree, depending on the region.

IPCC Fourth Assessment Report 2007
www.ipcc-wg2.org

Scientific Facts on Climate Change
www.greenfacts.org/en/climate-change-ar4

Agriculture is affected by the following factors of climate change:

- Average rise in temperature
- Changes in the total amount of precipitation and in its distribution
- Increase in the atmospheric carbon dioxide concentration
- Degree of air pollution, for example with ozone
- Frequent occurrence of extreme weather events

Agriculture and Food Supply
<http://epa.gov/climatechange/effects/agriculture.html>

An important role is attributed to the time period within which changes are expected to occur. The consequences will not be felt equally soon in all regions.

According to the authors of the working group II of the IPCC: *"Crop productivity is expected to increase slightly at mid to high latitudes for local mean temperature increases of up to 1–3°C, depending on the crop, and then decrease beyond that in some regions."*

At lower latitudes, especially in seasonally dry and tropical regions, crop productivity is projected to decrease even for small local temperature increases (1–2°C), leading to a growing risk of hunger.

Globally, the potential for food production is projected to increase with rises in local average temperature over a range of 1–3°C. Beyond, it is projected to decrease.

An increased frequency of drought and flood occurrence is expected to have a negative impact on local crop production, especially in subsistence sectors at low latitudes."

... livelihoods and food security

These projections clearly indicate that the impact of climate change will be felt most in the countries of the South. In these regions, climate change will aggravate existing problems such as land degradation and water stress. The high dependency of large parts of these populations on agriculture increases their vulnerability to climate change. Subsistence farmers, in particular, will be very directly affected by any yield loss. Many of these people do not have the financial means and the know-how required to adapt to changing conditions.

The exact extent of the threat climate change poses to human food security is difficult to predict and depends on the scenario: *"Under moderate scenarios, climate change appears to have a negligible effect on the numbers of people at risk to hunger."* In a first phase, yield losses in the developing countries will probably be compensated by yield increases in the countries of the North. However, the question arises of how food will be distributed among the world's regions. Especially the poorest people will hardly be able to afford food produced in the North.

Other sources indicate that a global temperature rise of 3°C or more will expose 600 million people to the risk of hunger.

However, it is crucial to remember that climate change is not the only factor influencing future food security. Other important factors are population growth, trade, and the distribution of food, among other things.

... potato farming

There are only few existing simulation models that can provide information on the influence of climate change specifically on potato farming.

Rising temperatures: A blessing and a curse...

A rise in temperature leads to increased transpiration in the plants, thus raising their demand for water. In many of the drier potato growing regions this will cause water stress, leading yields to decline. The effect will be further aggravated by changes in rainfall distribution.

Where there is no possibility of irrigation in these regions yields will decrease even further, down to the extent where potato growing will become altogether impossible. For several countries, particularly in the tropics and subtropics, yield declines are expected to reach up to 20–30%. Overnight

Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change: Summary for Policymakers.
p. 11. www.ipcc-wg2.org

Vulnerability

The vulnerability of people in a given area to the effects of climate change depends on two key factors:

- Vulnerability of the surrounding natural landscape unit to weather extremes and climate shift
- The adaptive capacity of the local population

Adaptation to Climate Change

www.gtz.de/de/dokumente/en-climate-adaptation-info.pdf

Climate Change, Agricultural Policy and Poverty Reduction – How much do we know?
www.odi.org.uk/publications/nrp/NRP109.pdf

Changes in potential yield induced by climate change in the period of 2040–2059.
(Hijmans. 2003)

Country	Changes in potential yield (%)	
	Without Adaptation	With Adaptation
China	-22,2	-2,5
India	-23,1	-22,1
Russia	-24,0	-8,8
Bolivia	+8,4	+76,8
Peru	-5,7	+5,8
Nepal	-18,3	-13,8
USA	-32,8	-5,9

However, in every one of these countries there are also regions where climate change will cause yields to increase – particularly if adaptation measures are taken.

The Effect of Climate Change on Global Potato Production: findarticles.com/p/articles/mi_qa4069/is_200307/ai_n9246054/print

temperature has a crucial influence on starch deposition in potato tubers. The ideal temperature range is between 15 and 18°C. Overnight temperatures above 22°C severely hamper tuber development.

By contrast, the impact of climate change on potato yields is expected to be favourable in cultivation areas at higher altitudes. In many of these areas the climatic conditions for potato growing are improving due to the rising temperatures. This boosts yields and leads to an expansion of potato production to both higher altitudes and higher latitudes. In some regions it will become possible to grow potatoes as a winter crop.

However, the expansion of potato cultivation to higher altitudes also bears risks. High-altitude cropland is often situated on steep slopes, where growing potatoes can aggravate soil degradation due to the high degree of tillage involved. More research needs to be done regarding the effect that the stronger ultraviolet radiation at higher altitudes has on potatoes.

Higher yields due to higher CO₂ concentration?

The increased CO₂ concentration associated with climate change has a positive effect on crop yields when examined as an isolated factor. Under laboratory conditions this effect is particularly pronounced for potatoes and other tubers. Therefore, some researchers consider CO₂ fertilising a possible measure to curb yield losses due to climate change. However, the interaction between increased CO₂ concentration and higher temperatures is not yet sufficiently examined to make reliable statements regarding their effects on tuber development in potatoes. Newest findings suggest that under field conditions the positive effects of high CO₂ concentrations observed in the lab will prove to be considerably lower than previously expected.

Disease and pest pressure might increase

In some regions, disease and pest pressure on potato production will increase due to climate change.

Late blight is expected to expand into areas that have previously been fairly safe from this disease. Moreover, it is very probable that in certain regions aphids will occur in greater number and in different seasons than so far due to more favourable climatic conditions. As virus vectors, aphids represent a threat particularly to seed production. At present, seed is cultivated at high altitudes and prior to the seasonal occurrence of aphids in order to keep it virus free.

Wild potato species in jeopardy

The growing temperature increase puts additional pressure on the potato's wild relatives. 16–22 % of all wild potato species are threatened with extinction by the year 2055. This is a dangerous situation, since wild relatives are important gene pools for breeding new varieties.

Reddy and Hodges, 2000
Climate change and Global Crop Productivity

Insects feel the heat
Rapport sur le site CIP:
[www.cipotato.org/publications/
annual_reports/2001/08.asp](http://www.cipotato.org/publications/annual_reports/2001/08.asp)

*Climate Change Threatens Wild Relatives
of Key Crops*
[http://news.biodiversityinternational.org/
index.php?itemid=1783](http://news.biodiversityinternational.org/index.php?itemid=1783)

What are the options for agriculture?

Given that certain effects of climate change are already being felt, climate change must be addressed with a combination of effective climate protection measures, on the one hand, and adaptation measures, on the other hand. Basic climate protection measures and binding objectives were established in the Kyoto Protocol to the United Nations Framework Convention on Climate Change. In the agricultural sector, several organisations – including the Food and Agriculture Organisation (FAO) and the international agricultural research centres of the Consultative Group on International Agricultural Research (CGIAR) – have elaborated measures to support the most severely affected countries.

Adaptation

Climate change underlines the importance of sustainable agricultural production systems. The more stable an agricultural ecosystem, the better it can cope with the additional stress factors induced by climate change. Sustainable resource use and sustainable land management are efficient ways to strengthen an agricultural system. Each of the individual measures to enhance sustainability has several positive effects. Mulching, for example, can raise the content of organic matter in the soil. This, in turn, increases the soil's water holding capacity, thus reducing runoff and erosion and making more water available to plants. Sustainable water use can also be achieved through improved irrigation systems, one example of which is drip-irrigation. Such systems need not be expensive. In some developing countries such as, for example, India, low-cost micro-irrigation systems are produced locally and at a relatively moderate price. Mixing varieties and intercropping (growing multiple crops on one plot) lead to more biodiversity within a plot, thereby also reducing this plot's vulnerability to different weather impacts. In many cases, research can learn from the knowledge of farmers in marginalised regions. Among other things, farmers adapt the sowing time to changes in the onset of the rainy season, or they react to shorter growing seasons by adapting their cultivation methods. These measures are not always sufficient. Further steps must be taken. High importance is ascribed above all to developing and breeding heat and drought resistant varieties. Furthermore, there is a need for strengthening rural institutions, and for access to micro-credits, micro-insurance, and climate information. All these measures require funding and support by national and international organisations. Particularly the most heavily affected poor rural populations are in urgent need of such support.

Mitigation

Agriculture has the potential of reducing greenhouse gas emissions without making large financial investments. Often, these measures have additional positive effects. The most crucial issue is reducing forest clearances for agricultural purposes. Agroforestry systems can be a viable alternative. Moreover, zero tillage can raise soil organic matter content, at the same time preventing erosion and binding CO₂ in the soil. New rice varieties that require less water also reduce methane emissions, and reduced nitrate loss during fertilising also diminishes emission of N₂O.

CGIAR: Climate Change Can Agriculture Cope?
www.cgiar.org/impact/global/climate.html

FAO: Adaptation to climate change in agriculture, forestry and fishery: Perspective, framework and priorities
www.fao.org/sd/dim_en1/en1_070401_en.htm

Adaptation and mitigation of climate change in agriculture

The greater uncertainty from climate change can best be addressed through contingency planning across sectors. Many of the least developed countries (LDC) are preparing national adaptation plans of action (NAPA) to identify immediate priorities in improving preparedness for climate change. Mainstreaming climate change in the broader economic agenda rather than taking a narrow agricultural perspective will be crucial in implementing these plans.

Agriculture for Development
www.worldbank.org/wdr2008

A need for concrete action

Adaptation to Climate Change
www.gtz.de/de/dokumente/en-climate-adaptation-info.pdf

Climate adaptation tools:
www.iisd.org/pdf/2007/sharing_climate_adaptation_tools.pdf

CRISTAL: Community-based Risk Screening – Adaptation and Livelihoods
More information is available on the following
www.iisd.org/security/es/resilience/climate_phase2.asp

ADAPT: A tool to screen for climate risk
<http://go.worldbank.org/Z02IYEC0JO>

Centro Internacional de la Papa
www.cipotato.org

Vulnerability assessment

International and local institutions, as well as governments, must be aware of the impact of climate change. They must include these impacts in their planning and devise measures to counteract them. However, this is difficult: *“... at present, there is virtually no experience of how to manage this adaptation process. There are scarcely any systematic risk assessments predicting who will be affected and when...”*

In a first step, vulnerability to climate change must be assessed. Only once it is known how heavily the various areas, crops, population groups, etc. will be affected by the impacts of climate change, is it possible to define measures. Several tools have been developed to assess the vulnerability of individual projects. Two of them shall briefly be presented below.

CRISTAL is a computer-based decision-support tool that helps to reveal risks related to climate change in project planning. In a second step, the tool suggests options for adaptation. The objective is to illustrate the interlinkages between climate, livelihood, and project activities.

ADAPT, developed by the World Bank, is a computer-based tool to screen development projects for climate risks. The programme uses various climate change scenarios, linking them to planned project activities in order to determine the project's vulnerability to failure due to climate change. The tool is intended for use by development cooperation practitioners who are planning new projects.

The International Potato Center (CIP) has developed a simulation model that succeeds in simulating and visualising different climate scenarios and their influence on potato production. The model is based on a geographic information system (GIS) in which users can enter the variables for precipitation, temperature, soil, and different potato varieties. The output consists of estimates regarding the future development of potato production, including yield estimates, for the given region. The possibility of downscaling and interpolating available climate data has greatly enhanced the precision of projections and makes the model applicable to much smaller areas. Farmers and researchers can therefore use it as a support tool for making decisions with regard to potato growing. Simulation models are also used in breeding new varieties in order to simulate the impacts of new heat and drought resistant cultivars under certain climatic conditions.

Three scenarios for potato farming

Depending on a region's vulnerability, different measures need to be taken. Potato producers, for example, face three options for reacting to the changed conditions.

Abandonment of production

Should climate change lead to a drastic deterioration in growing conditions, farmers in certain regions will have to consider abandoning potato production.

The Sikasso area in southern Mali can serve as an example. In recent years, the government and international donors supported strong promotion of

Integrating Climate Change Adaptation into Development
http://unfccc.int/files/adaptation/adverse_effects_and_response_measures_art_48/application/pdf/200609_usa_north_south.pdf

potato production and marketing in the area. Due to climate change, these efforts are now put into question, and project partners are thinking of stopping potato production altogether as an ultimate adaptation measure.

Expansion into new areas

In other areas, potato cultivation is only being made possible or can be intensified due to climate change. In some regions in China, for example, potatoes are expected to become a possible winter crop. However, when introducing potatoes as an entirely new crop, it is crucial to consider possible negative consequences.

Adaptation of production

In many areas adaptation measures will be necessary in order to maintain production or reduce yield losses. Several possible adaptation measures and considerations regarding potato production are presented in the following section.

Growing importance of weather forecasts

Information on climate change and its impact are of great value to farmers. For example, early warning systems can alert the population about imminent storms and enable them to take protection measures in time. Medium range weather forecasts can be particularly useful for planning crop schedules. In many places, farmers rely heavily on traditional weather forecasting methods. Climate change is increasingly causing these methods to lose their validity, and the weather is becoming more difficult to predict. As a result, scientific weather forecasts are gaining importance. However, many farmers are sceptical towards scientifically produced forecasts despite the fact that their traditional forecasts are becoming less and less reliable. A study reports farmers in the Andes to have claimed that forecasts produced in distant weather stations were of no use to their region. As a rule, they relied much more on forecasts by local experts than on those produced by professional weather services. For planning their crop schedule they usually looked to the most successful producers in the area, whose short- and long-range weather forecasts were based on observation of the stars and other natural phenomena. In order for scientific weather forecasts to benefit the farmers despite their scepticism, local experts must be convinced to cooperate and help professional weather services to reach farmers better by providing locally adapted solutions.

Breeding new varieties – a key to success

Both researchers and farmers see an urgent need for breeding new potato varieties that are better adapted to the changing climatic conditions. Particular efforts in this respect are made at the International Potato Center (CIP), where the main focus is on breeding short-season varieties. Due to their shorter vegetation periods, these varieties make it easier for farmers to avoid unfavourable conditions such as hot or dry periods and react to modified rainfall patterns.

Climate change confronts breeders with an enormous challenge. Normally, they work to improve one specific characteristic of a crop, whereas climate change has created a need for adapting several characteristics at once.

Climate Variability and Household Welfare in the Andes: Farmer adaptation and use of weather forecasts in decision-making
www.climate.noaa.gov/cpo_pa/sarp/1999_valdivia_final.pdf

Vulnerabilidad y Adaptación al Cambio Climático en las Regiones del Lago Titicaca y los Valles Cruceños de Bolivia
www.nlcap.net/fileadmin/NCAP/Countries/Bolivia/Bolivia_V_A_REPORT01-02-06.pdf

Centro Internacional de la Papa (CIP)
 Aside from breeding efforts, the CIP also develops methods of analysis and simulation models to improve projections regarding the impact of climate change on potato production, as well as specific adaptation measures. These include, for example, recommendations regarding cultivation methods for sustainable potato production, which are aimed at enhancing the capacity of potato production systems to react to the impacts of climate change.
www.cipotato.org

PROINPA

PROINPA was founded in 1989 as a mandate of the International Potato Center (CIP) in collaboration with the Instituto Boliviano de Tecnología Agropecuario (IBTA), with the aim of enhancing productivity in potato cultivation in the Andean valleys and on the Altiplano. Today, PROINPA is a nationally and internationally renowned centre of competence.

PROINPA offers research services and consultancy, as well as training modules for a wide range of Andean products, particularly potatoes, quinoa and other grain and tuber crops. Among other things, PROINPA is mandated by the government to manage genebanks of Andean grain crops. www.proinpa.org

Diversity is a chance

"The great diversity of potatoes in the Andes is the key to success in breeding new varieties that are better adapted to the multiple challenges of climate change. Ultimately, this diversity will help to secure the survival of potato farmers."

Jorge Rojas, PROINPA (personal communication)

Therefore, the CIP is evaluating the genetic resources of its potato collection, and also of new varieties still in the process of being bred, with regard to their tolerance of water and temperature stress. The CIP can draw on the world's largest genetic reservoir of potato varieties: its genebank contains 5000 distinct types of cultivated potatoes, as well as more than 2000 wild relatives of the potato belonging to around 140 wild species. The goal is to identify the desired key characteristics and genes that determine tolerance of abiotic stress by means of various selection methods and marker systems.

Early-maturing potatoes for shorter rainy seasons

The Fundación para Promoción e investigación de productos andinos (PROINPA) in Bolivia, together with the CIP, is in the process of launching a new potato breeding project in order to be able to react to climatic changes. In recent years, some areas in Bolivia have been experiencing changes in the onset of the rainy season. Previously, farmers would start planting their potatoes in October, at the onset of the rain. Today, the rainy season often begins as late as December, whereas it still ends in March, as it always has, confronting farmers with drastically shorter growing periods. Traditional potato varieties are not adapted to these short rainy seasons and thus produce low yields. Further progression of climate change can therefore threaten the food security of large parts of the population.

Until now, many potato farmers have been growing several varieties on one plot in an attempt to minimise the risk of yield loss due to diseases, pests, and adverse weather. Jorge Rojas of PROINPA doubts that this will be sufficient as an adaptation measure in future. According to his observations, climate change appears to take a particularly radical form in the Andes, not leaving farmers enough time for slow adjustment. They need assistance and support, particularly with regard to breeding new varieties.

PROINPA has launched a project to breed potato varieties that are better adapted to the short rainy season and do not produce lower yields due to the new seasonal regime. The project is designed to involve farmers very closely by testing new varieties on their fields, under real conditions, as early as possible.

Wild relatives – an important gene pool

Success in breeding better adapted varieties depends on collection, preservation and dissemination of the relevant genetic material. Wild relatives play an important part in breeding abiotic stress tolerant varieties. Their great genetic variability makes them important genetic resources for producing the desired characteristics. Until now, wild relatives have rarely been used for breeding purposes because they frequently have many undesirable characteristics aside from the desired ones. Breeding with wild relatives still needs time to be further developed, since it requires sound experience. Climate change and other factors that additionally increase pressure on ecosystems are threatening the existence of many wild relatives. The establishment and maintenance of genebanks is intended to curb the loss of this diversity in varieties.

The genetic resources of the potato are preserved in the form of true potato seeds, vegetative tubers, and in vitro seedlings. With regard to potatoes, in particular, conservation under in situ conditions is considered an important strategy to preserve the genetic resources. In situ conservation involves exposing the varieties in question to natural conditions in the field. This initiates a process of selection and, perhaps, even adaptation to the changing climatic environment.

Experts have devised strategies for improving conservation and use of crop genetic resources. To date there are around 1400 genebanks worldwide, containing approximately 6 million samples of crop genetic resources. Three quarters of them are located at CGIAR centres.

In future, genetic resources for such collections need to be selected more according to the newly required crop characteristics, such as, for example, drought tolerance. In addition, collections and particularly their diversity must be extended to include more wild species and land races. In view of the fact that it takes 12–20 years to breed a new variety, researchers have not been able to answer the question of how well the existing genetic resources are suited for meeting the challenge of climate change.

Genetic diversity and its use

The potato provides one of the starkest warnings against the loss of crop diversity. In the 19th century Ireland a devastating potato disease – potato blight – wiped out the potato crop and resulted in the deaths of more than a million people and the emigration of a similar number. The country had been reliant on one variety of one crop for its staple food, and that variety had no resistance to the disease. There was no significant genetic diversity in the crop to provide protection. This grim story still serves as reminder of the danger of genetic erosion and the need to maintain as much variety as possible in our staple crops.

Global Crop Diversity Trust

www.croptrust.org/main/priority.php?itemid=28

The conservation of global genetic resources in the face of climate change:

http://se.stanford.edu/events/conservation_of_crop_genetic_resources_in_the_face_of_climate_change

www.planttreaty.org

What can potato farmers expect from the future?

Will potato farmer Padam Damai (see p. 1) be able to keep up his production, and will his children be able to grow potatoes in 30 years?

Despite the numerous model calculations and projections we currently still know much too little about climate change and its impact on agriculture. Time will show how potatoes will actually react to the changing climatic conditions.

Farmers who are cultivating potatoes in regions where conditions are critical even today, may no longer be able to do so a few years from now. They will have to find other crops or engage in off-farm activities. Most of them will be forced to adapt. They have already been able to implement some adjustments or will be able to do so in future without outside help. For other measures they need external support.

At the policy level, mainstreaming climate change into national programmes and strategies is highly important as a prerequisite for timely assessment of vulnerabilities, as well as planning and implementation of measures.

There are no simple recipes for the implementation of these strategies. Each country requires the strategy best suited for this country's specific situation.

Many of the least developed countries (LDC) have formulated such strategies in their National Adaptation Programmes of Action (NAPAs). These programmes identify vulnerabilities to climate change and point out first urgent adaptation measures.

In agriculture, and particularly in potato production, much depends on successful breeding of new varieties. If researchers succeed in breeding more stress resistant varieties that produce sufficient yields even under changed conditions, potatoes will continue to be able to be grown in many regions also in future.

One issue will become increasingly important as water stress increases: water productivity. This characteristic refers to the amount of "crop per drop" a plant produces.

With yields of 6.2–11.6 kg per m³, potatoes have a higher water productivity than rice, wheat, and maize.

The International Potato Center (CIP) sees a chance that potatoes will continue to make an important contribution to food and income security in future:

Given the potato's high productivity per unit of land and time and value, as both a staple and a cash crop, increasing stress tolerance in potato has a great potential to contribute to food and income security, mitigate poverty, and reduce farmers' risk in vulnerable agricultural environments (CIP, personal communication).

National Adaptation Programmes of Action (NAPAs)
unfccc.int/adaptation/napas/items/2679.php

Crop water productivity is the amount of water required per unit of yield and a vital parameter to assess the performance of irrigated and rainfed agriculture.
Crop Water Productivity Programme
www.fao.org/ag/AGL/aglw/cropwater/cwp.stm

Recommended reading

The following list features a documented and targeted selection of print documents and Internet sites of relevance to "Potatoes and Climate Change". For easier reading they have been allocated to four rubrics: **Overview**, **Policy**, **Instruments**, **Case studies**. The documents are listed by title in alphabetical order. Most of them are available online (accessed on April 2008).

World Bank. 2008

Overview

Adaptation to and Mitigation of Climate Change in Agriculture

Policy

In: World Development Report 2008: Agriculture for Development. 201–202.

http://siteresources.worldbank.org/INTWDR2008/Resources/2795087-1192112387976/WDR08_15_Focus_F.pdf

The World Bank has devoted one section of its World Development Report entitled "Agriculture for Development" to the topic of climate change and agriculture. This section points out several options for adapting agriculture to the impacts of climate change, and gives brief outlines of several mitigation measures.

GTZ. 2007

Overview

Adaptation to Climate Change

Policy

Causes, Impacts, Responses. 8 p. www.gtz.de/de/dokumente/en-climate-adaptation-info.pdf

This publication provides a good introduction to the issue of climate change. It points out why adaptation is so important, and presents several small projects. GTZ encourages organisations who have developed innovative ideas for adaptation to contact GTZ.

IIED. 2007

Overview

Adaptation to Climate Change

How we are set to cope with the impacts. IIED Briefing. 4 p. www.iied.org/pubs/pdfs/17006IIED.pdf

This clearly structured publication gives a brief definition of adaptation in the context of climate change and lists current international, national and local adaptation strategies. It also provides definitions of terminology related to adaptation.

FAO. 2007

Overview

Adaptation to Climate Change in Agriculture, Forestry and Fisheries:

Policy

Perspective, Framework and Priorities, Interdepartmental Working Group on Climate Change

24 p. <ftp://ftp.fao.org/docrep/fao/009/j9271e/j9271e.pdf>

In this document, the Food and Agriculture Organisation (FAO) points out possible ways for agriculture, forestry and fisheries to address climate change. Adaptation measures for various production systems are outlined and illustrated by means of examples.

Pescett, Leo. 2007

Overview

A rough guide to climate change and agriculture

Draft. Overseas Development Institute. 26 p. www.odi.org.uk/plag/RESOURCES/other/07_cc_ag-1.pdf

This publication provides a brief overview of what makes climate change so important for agriculture. It explains the research methods used to examine the impacts of climate change, and introduces different models and their specific problems. Comparative tables give an impression of how human food security might be influenced by climate change according to the various models.

Intergovernmental Panel on Climate Change. 2007

Overview

Climate Change 2007

Working Group II Report "Impacts, Adaptation and Vulnerability". www.ipcc-wg2.org

This publication constitutes a part of the IPCC Fourth Assessment Report on climate change. It offers an overview of the impacts of climate change on mankind and the environment in the various regions of the world, an evaluation of the main vulnerabilities, and an outlook on options for adaptation. IPCC reports enjoy worldwide renown as the main reference for political and scientific decisions.

Overview

Rachel Slater, Leo Peskett, Eva Ludi, David Brown. 2007

Climate Change, Agricultural Policy and Poverty Reduction – How much do we know?

Natural Resource Perspectives 109. Overseas Development Institute. 6 p. www.odi.org.uk/publications/nrp/NRP109.pdf

This issue of Natural Resource Perspectives states that predictions regarding the impact of climate change on agriculture still contain major uncertainties. The influences of climate change on trade, food security and poverty reduction are presented.

Overview

K. R. Reddy and H. R. Hodges, (eds). 2000

Climate Change and Global Crop Productivity

CABI Publishing Wallingford UK ISBN 0-85199-439-3. 472 p.

This volume offers a scientific description of possible effects of climate change on the production of various crops, such as cereals, soy, cotton, vegetables and tubers, but also on pastures, trees and wildlife parks. The book describes adaptation strategies involving various crop breeding methods, and explores the role of biotechnology, as well as the economic and social impacts of climate change.

Overview

Climate Change Threatens Wild Relatives of Key Crops

<http://news.biodiversityinternational.org/index.php?itemid=1783>

This article summarises the results of a study stating that the potato's wild relatives are endangered by climate change. Valuable genetic resources are at risk of disappearing.

Case studies

Corinne Valdivia, Jere L. Gilles, Roberto Quiroz, Christian Jetté. 2003

Climate Variability and Household Welfare in the Andes:

Farmer adaptation and use of weather forecasts in decision-making,

Final Report submitted to NOAA's Human Dimension of Global Change Research Programme.

24 p. www.climate.noaa.gov/cpo_pa/sarp/1999_valdivia_final.pdf

This project was designed to identify delivery systems of climatic information to Andean farmers by investigating their current use of local forecast information in making production and consumption decisions. The project revealed that farmers were able to adapt more or less successfully to climate variability even though they preferred traditional weather forecasting to scientific calculations.

Case studies

Franco Miglietta et al. 2000

Crop Ecosystem Responses to Climatic Change: Root and Tuberous Crops

In: Climate Change and Global Crop Productivity, CABI Publishing Wallingford UK ISBN 0-85199-439-3. 189–211.

The authors of this contribution have compiled various findings on possible effects of climate change on yield production in tubers such as potato and manioc. They conclude that it is difficult to predict the effects of climate change on tuber crops.

Overview

Greenfacts. 2007

Facts on Climate Change

A summary of the 2007 Assessment Report of the IPCC. www.greenfacts.org/en/climate-change-ar4/index.htm

Greenfacts, an independent not-for-profit organisation, has prepared a well-structured summary of the 2007 IPCC Assessment Report in the form of questions and answers. The summary is available for download on the Greenfacts website.

Overview

CGIAR. 2007

Global Climate Change: Can Agriculture Cope?

www.cgiar.org/impact/global/climate.html

This paper summarises efforts made at the various CGIAR research centres with regard to climate change, and presents various examples of adaptation and mitigation measures from the different sectors of agricultural production.

Overview

William R. Cline. 2007

Global Warming and Agriculture

Impact Estimates by Country. www.cgdev.org/content/publications/detail/14090

This book describes the impacts of climate change on agriculture along with their economic effects. The author discusses existing studies on the issue and makes recommendations for the policy level.

Overview

FAO. 2008

International Year of the Potato

FAO Factsheets. www.potato2008.org/en/potato/pdf.html

On the occasion of the International Year of the Potato, the FAO has produced an informative website describing the role of the potato in agriculture, economy, and global food security.

Various factsheets on key issues such as nutritional value, biodiversity, global production, profitability, biotechnology, diseases and pests can be downloaded as PDF files.

Instruments

International Institute for Sustainable Development, World Bank, Institute for Development Studies. 2007

Sharing climate adaptation tools

Improving decision-making for development, Geneva workshop 11.–12. April 2007. 10 p.

www.iisd.org/pdf/2007/sharing_climate_adaptation_tools.pdf

This paper introduces various tools that are presently used by development cooperation practitioners in connection with vulnerability and climate change. Each tool is briefly described, and the URL to its website indicated. A table comparing the tools according to various criteria offers an overview at one glance.

Overview

Policy

Simone Gigli und Shardul Agrawala. 2007

Stocktaking of Progress on Integrating Adaptation to Climate Change into Development Co-operation Activities

COM/ENV/EPOC/DCD/DAC(2007)1/FINAL, OECD, Paris. 83 p. www.oecd.org/dataoecd/11/18/39575695.pdf

This study by the OECD describes to what extent bilateral and multilateral development cooperation agencies and international financial institutions implement measures of adaptation to climate change in their development activities. The authors conclude that international donor organisations in development cooperation are well aware of the risks of climate change and the importance of considering them in development work. However, this awareness is usually not yet sufficiently transmitted to direct partners in developing countries. Mainstreaming of the issue is still very much neglected at the strategy and project level.

Instruments

International Institute for Sustainable Development. 2007

Summary of CRiSTAL

Community-Based Risk Screening Tool – Adaptation & Livelihood. 4 p. www.iisd.org/pdf/2007/brochure_cristal.pdf

This brochure briefly presents CRiSTAL, a tool that helps assess projects with regard to climate risks, and indicates the relevant contact addresses and the URL from which the tool can be downloaded.

Case studies

Robert J. Hijmans. 2003

The Effect of Climate Change on Global Potato Production

American Journal of Potato Research 80. 271–280.

http://findarticles.com/p/articles/mi_qa4069/is_200307/ai_n9246054

The author uses various simulation models to describe possible impacts of climate change on global potato production. His calculations are based on climate data from the past 40 years, as well as climate models for the coming 60 years. Without adaptation measures, most potato growing regions must expect partly high yield losses. Appropriate adjustments can curb these losses in many regions. Some regions will be able to profit from climate change.

Overview

The World Potato Atlas

<http://research.cip.cgiar.org/confluence/display/wpa/Home>

This website, maintained by the International Potato Center (CIP), contains a wealth of information on potato cultivation, particularly in selected developing countries. Information on production zones and production systems, seed production and varieties, as well as marketing and consumption are provided for the individual countries. Figures and maps visualise information on potato production in various regions.

Case studies

J. G. Iwanciw, J. C. Giles, M. A. Effen (eds.). 2006

Vulnerabilidad y adaptación al Cambio Climático en las Regiones del Lago Titicaca y Valles Cruceños de Bolivia

Sistematización de los Resultados de la Investigación Participativa, Consultas y Estudios de Caso, Ministerio de Planificación del desarrollo, Programa Nacional de Cambios Climáticos Bolivia. 138 p.
www.nlcap.net/fileadmin/NCAP/Countries/Bolivia/Bolivia_V_A_REPORT01-02-06.pdf

This study explores the sensitivity to climate change of agriculture and livelihoods in the mountainous region around Lake Titicaca, Bolivia.

InfoResources Focus provides a general overview of pertinent and topical subjects to guide one through the information jungle. Each issue focuses on a current theme relative to forests, agriculture, natural resources and the environment, in the context of international development cooperation. Each theme is viewed from several angles:

- Policies and strategies
- Implementation and practical experiences

The first section of *InfoResources Focus* proposes a brief introduction to each subject, highlights specific problems, compares theoretical approaches and opinions, and reports past experiences. The second section presents a selective and commented choice of documents, books, CD ROMs and Internet sites. The range of documents presented reaches from basic introductions, through instruments, methods and case studies, to conceptual texts. **Back issues of *InfoResources Focus*** can be ordered from the address given on page 2 or downloaded from www.inforesources.ch.